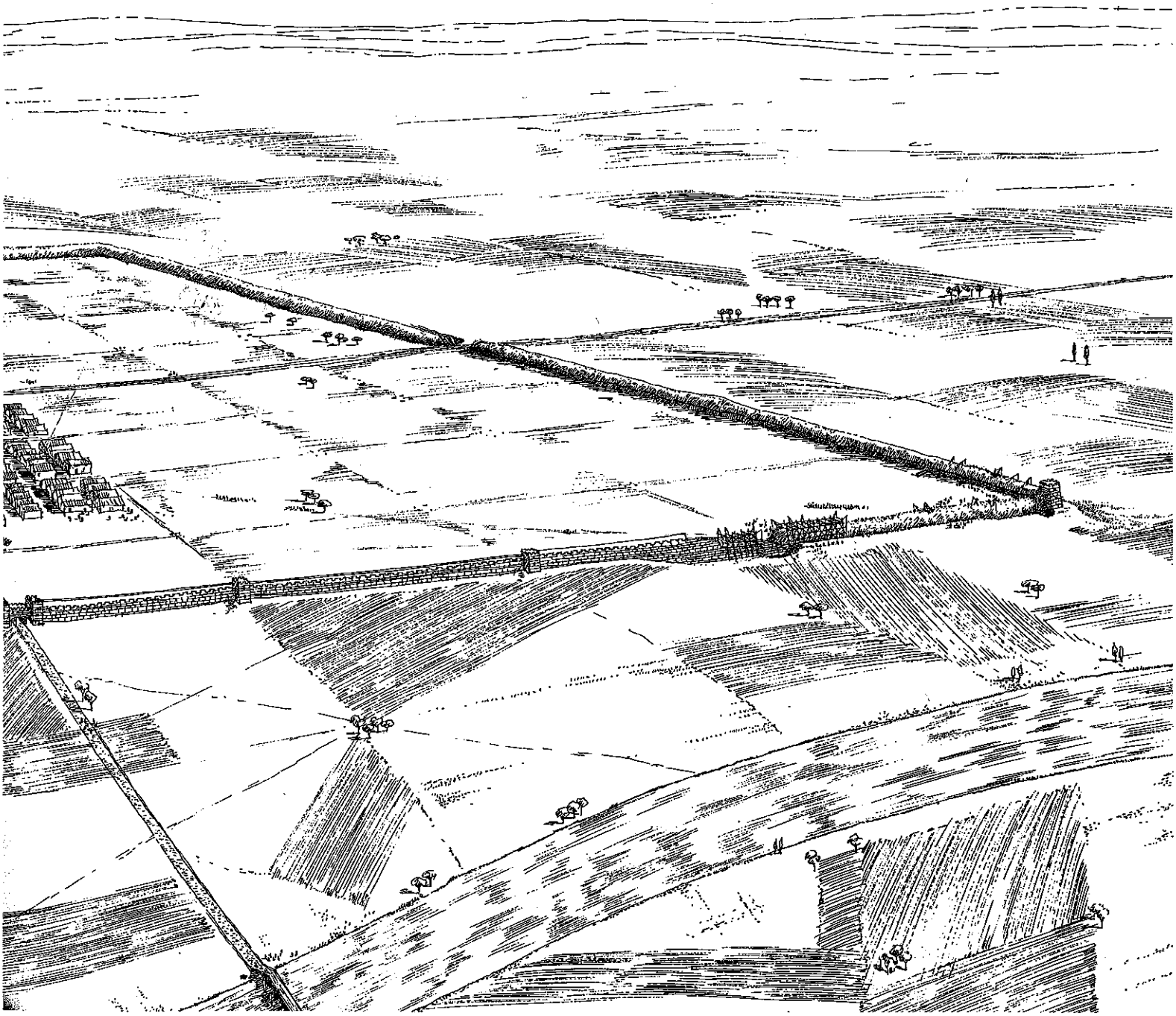
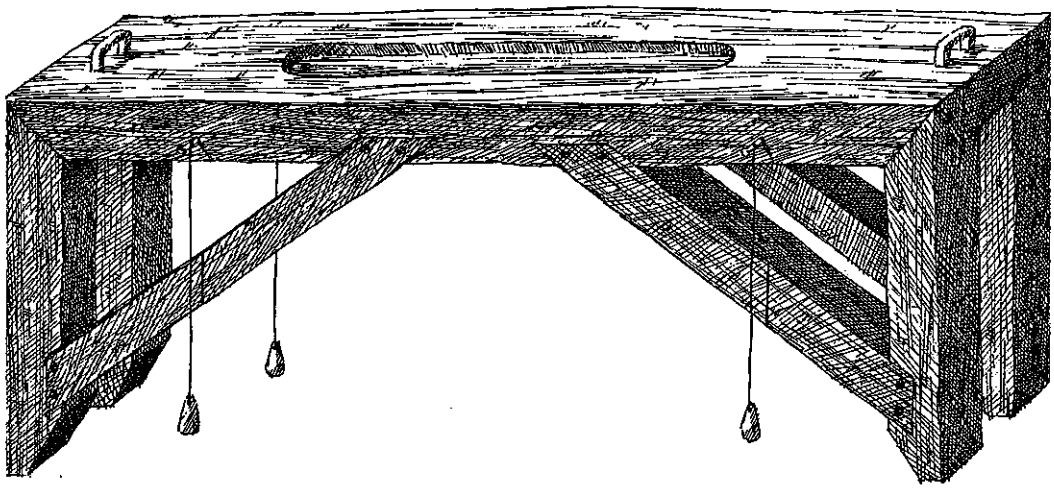
At first, Verbonia's drinking water came from several deep wells within the city walls. But the planners knew that as the population increased the wells would no longer be sufficient. A pipeline called an aqueduct was proposed to bring water from the mountain lakes thirty-eight miles to the south.



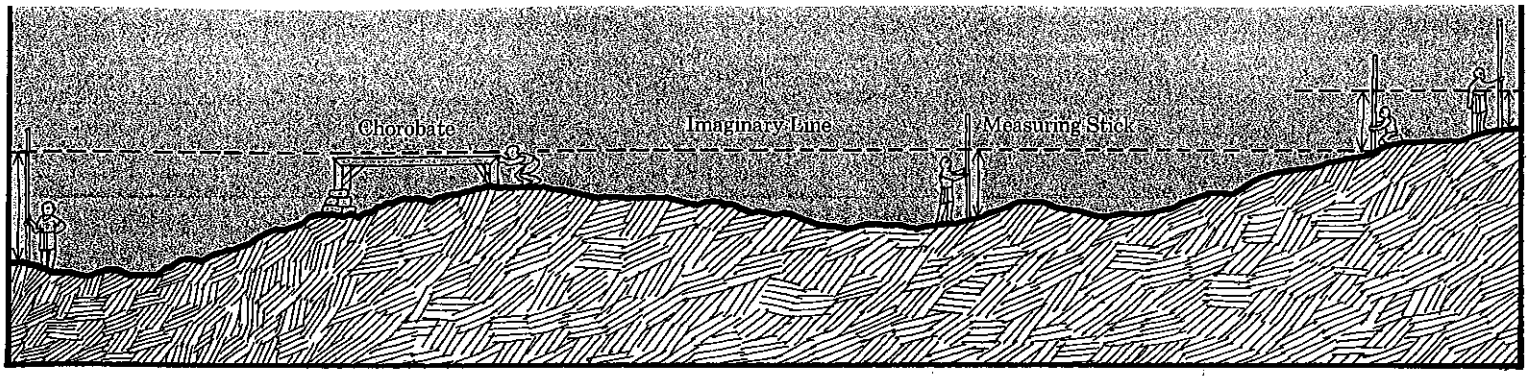
When the best route for the aqueduct had been chosen, a profile map of the land was drawn showing the hills and valleys. To determine the profile, surveyors used leveling instruments called chorobates. The chorobate was known to be level when weighted strings fastened to the horizontal bar hung parallel to the legs. This was double-checked by pouring water into a groove on top of the horizontal bar. When the distance between the top of the water and the top of the bar was the same all around the groove, the instrument was level.

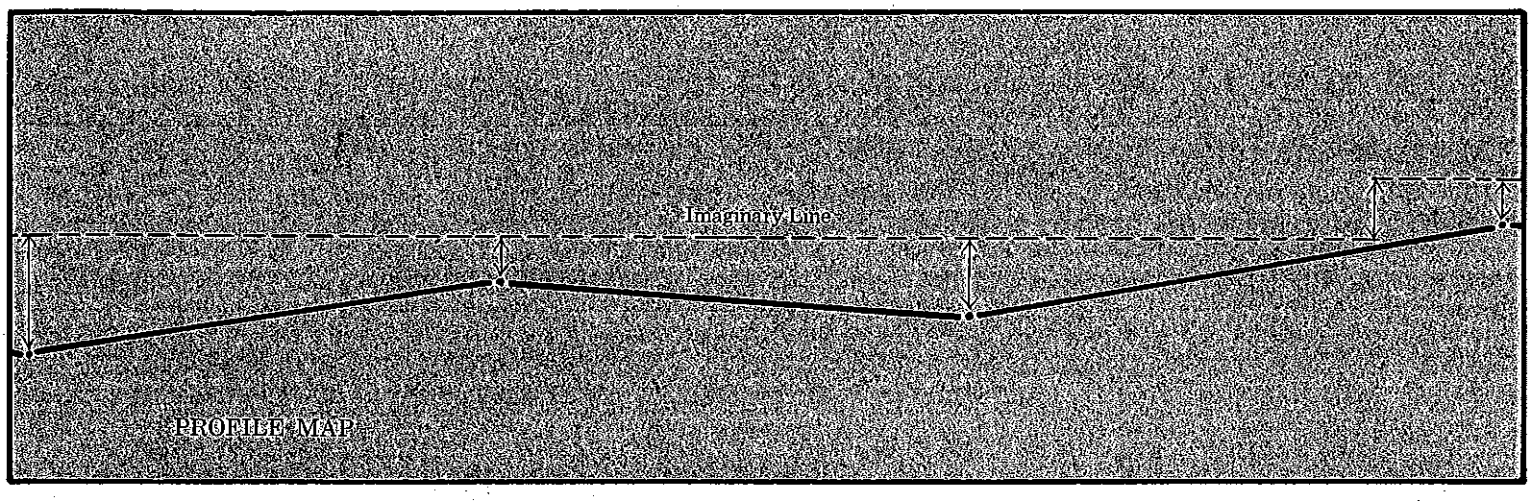


By sighting along the chorobate the surveyors were able to create an imaginary horizontal line over the entire route of the aqueduct. Every forty feet along this line the vertical distance between it and the ground was recorded. When the line was drawn on parchment the vertical distances were marked below it. By connecting all the marks with a single line the mapmakers obtained an accurate profile of the land. By then drawing the line of the aqueduct on the plan the engineers could easily see whether it would sit on the ground, cut through the ground, or rise above the ground.

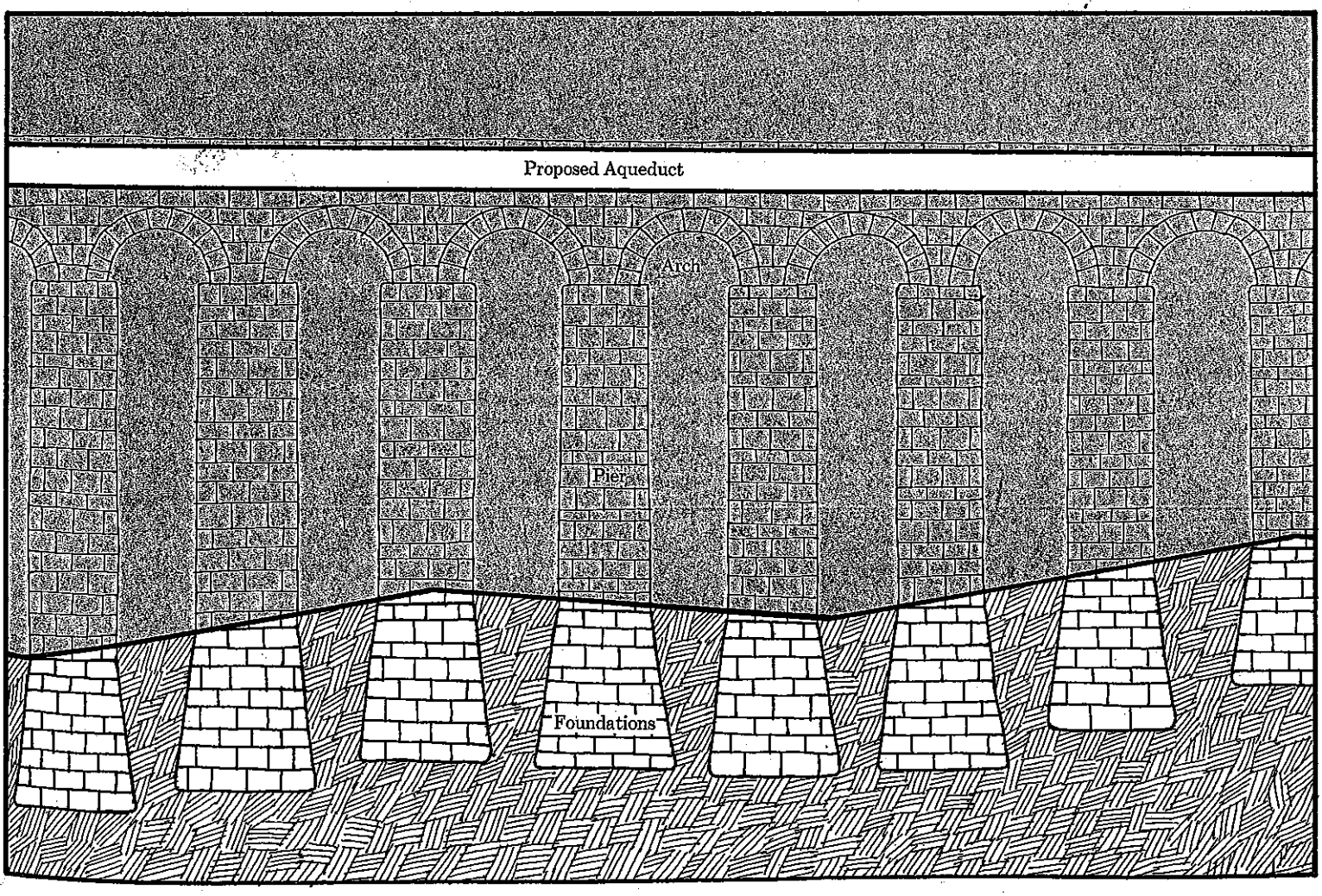
The aqueduct had to be built with a constant slope from beginning to end to keep the water moving.

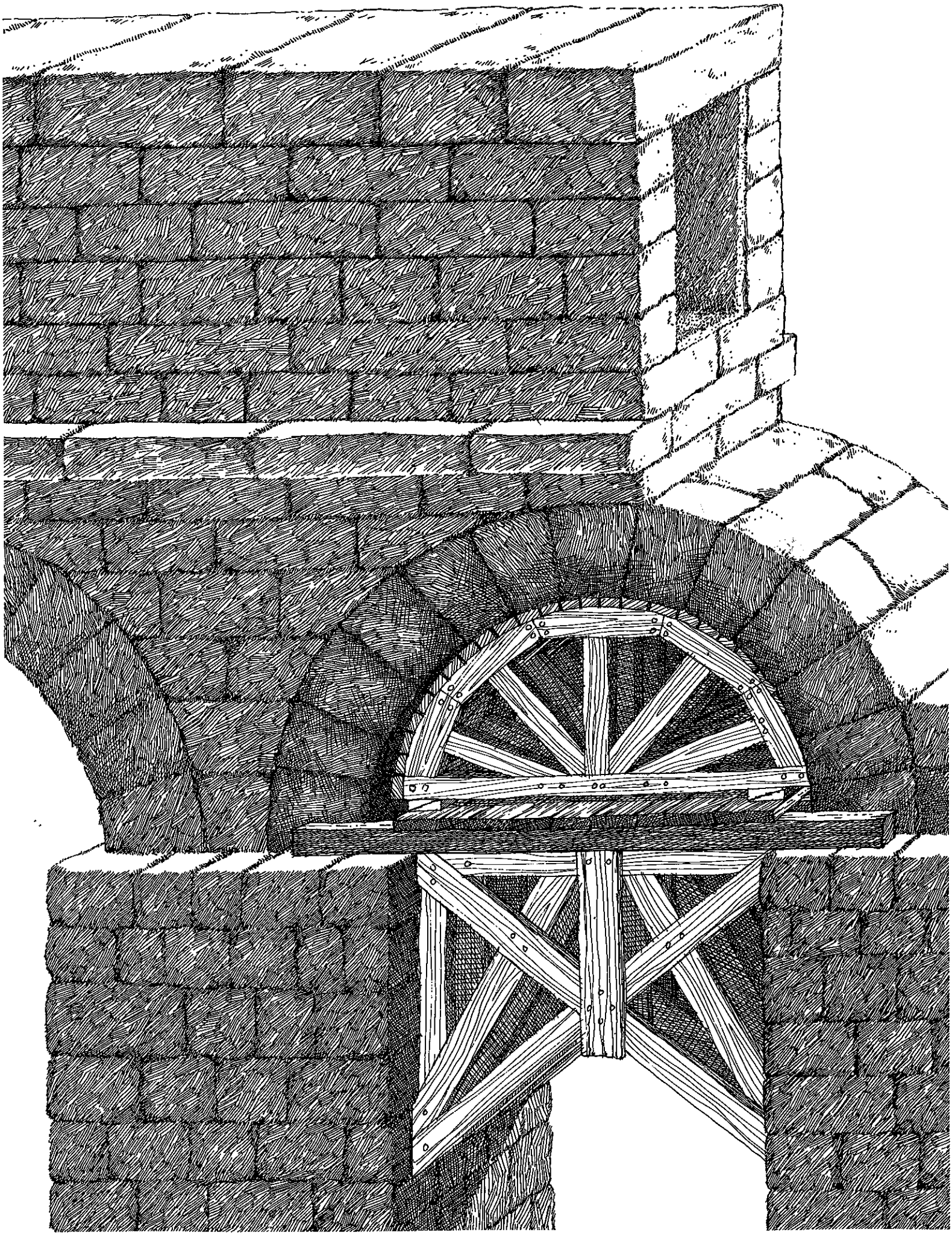
To prevent people from stealing or poisoning the water, most of the aqueduct was raised about fifty feet off the ground. It was supported by a continuous row of arches built on tall square piers which rested on deep foundations.


Chorobate
Imaginary Line
Measuring Stick


Imaginary Line

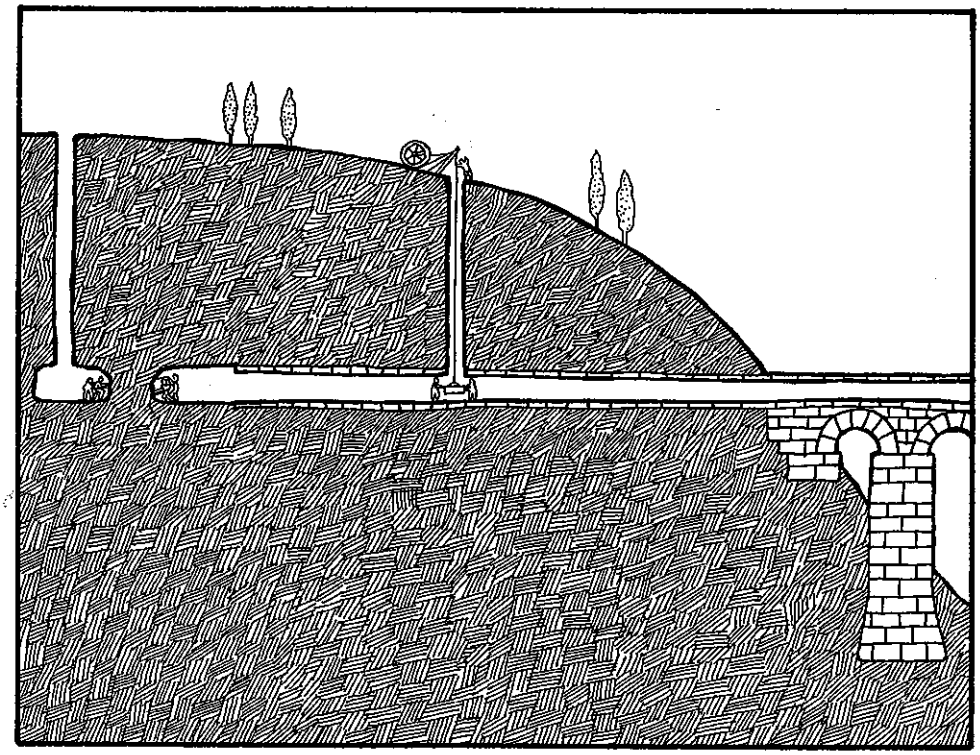
PROFILE MAP


Proposed Aqueduct
Arch
Pier
Foundations



The foundations and piers were constructed of stone-faced concrete — stone set in mortar on the outside with layers of concrete on the inside. To make the concrete, the masons first laid a course of rough stones across the area to be filled. The mortar men then covered the stones with a layer of mortar to bind them together. When the mortar had set, the process was repeated.

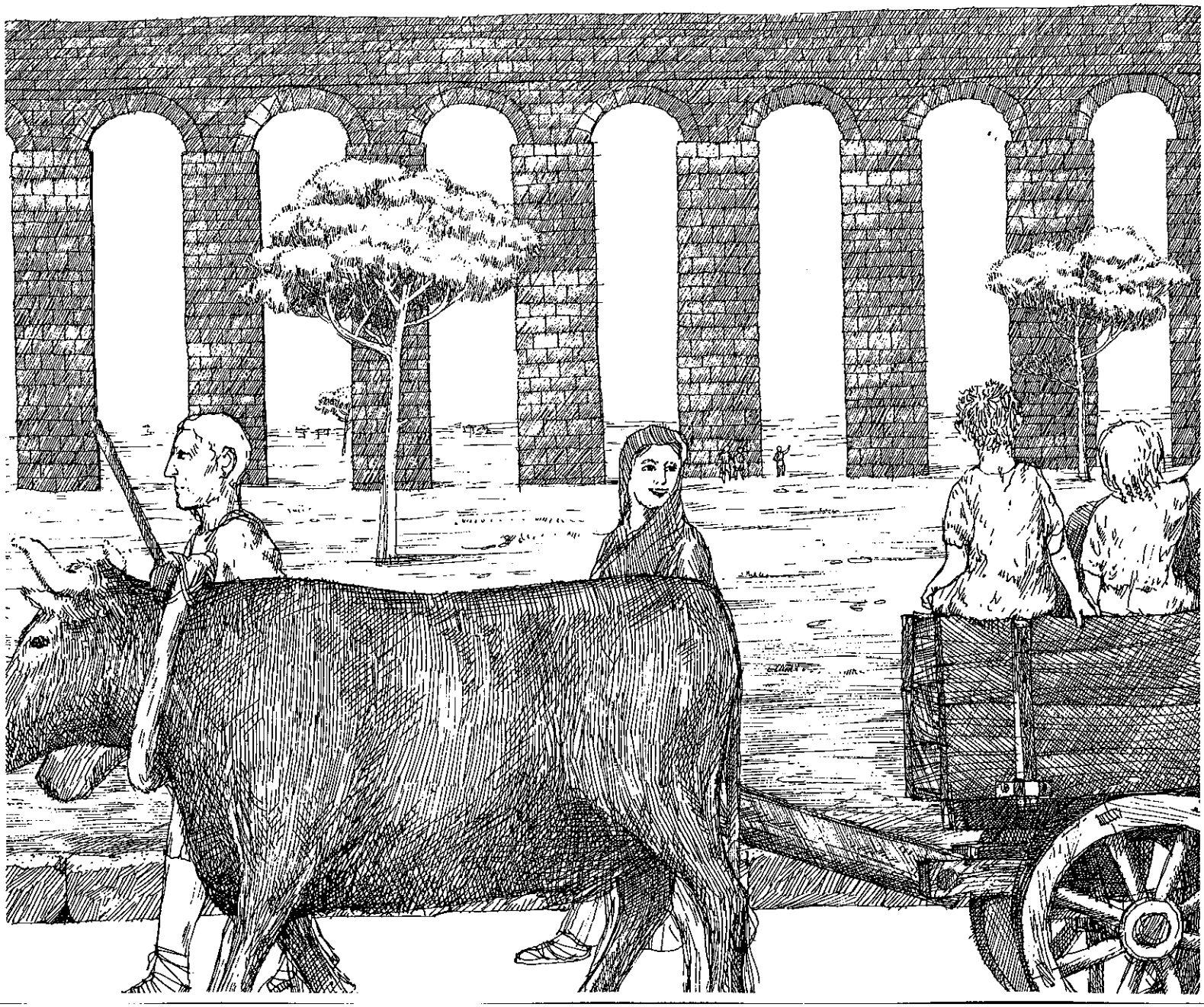
When two piers were finished, an arch was constructed between them. The aqueduct, itself a rectangular stone pipe about four feet wide and six feet high, was then built on top. The inner surface of the pipe was lined with hard cement to prevent leaks.



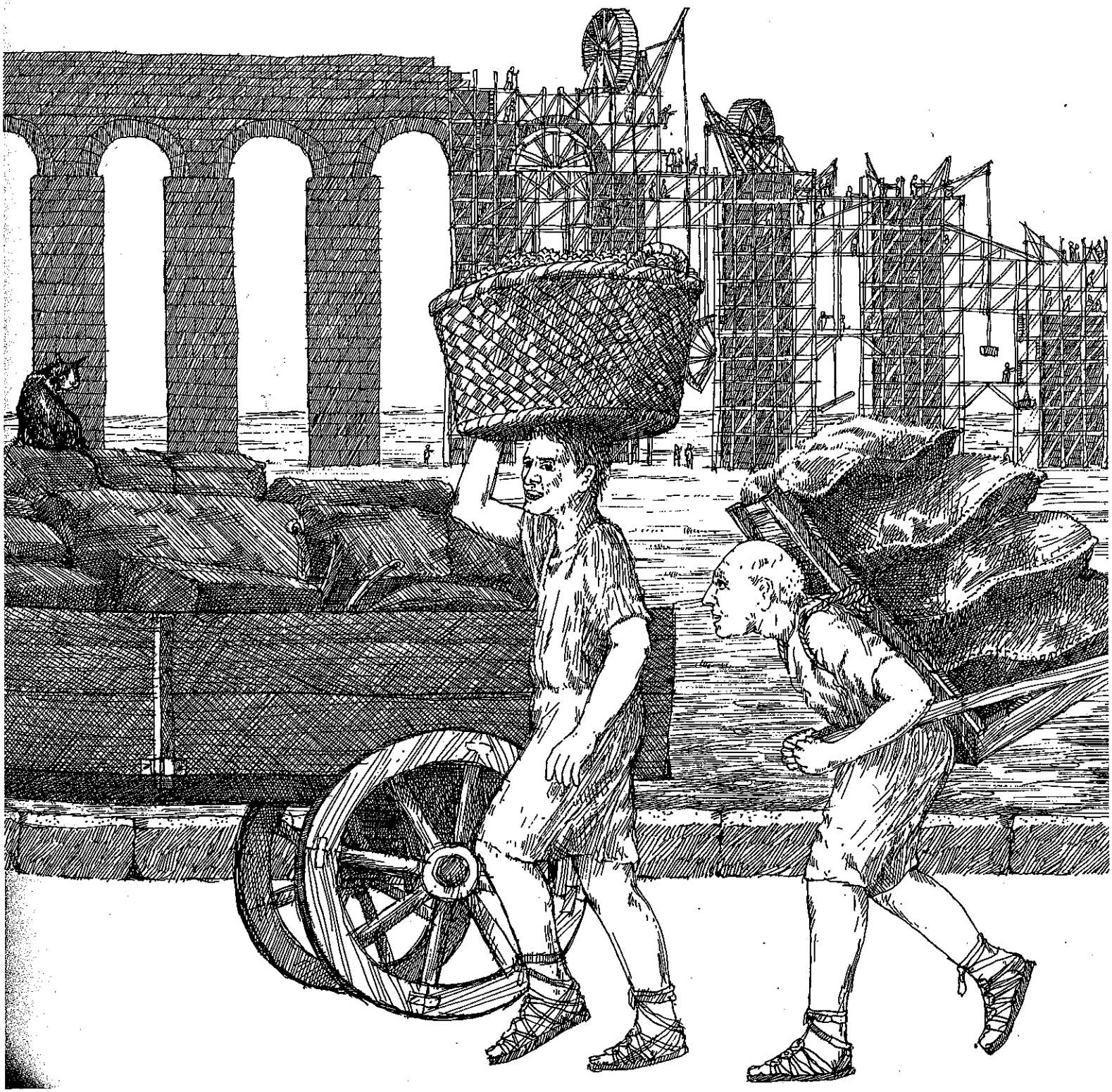
The route chosen for the aqueduct required that a short tunnel be dug through a hill. Every twenty yards vertical shafts were sunk from the surface of the hill to the level of the proposed aqueduct. The depths of the shafts were measured from the profile plan.

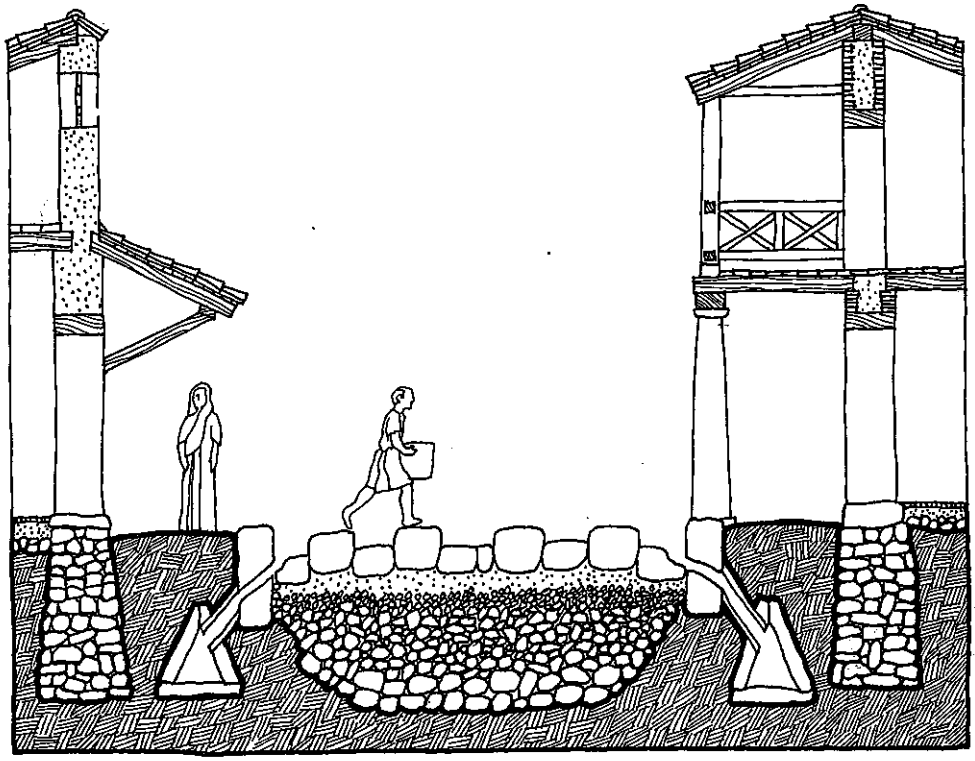
The laborers connected the ends of the shafts, and as a section was completed the masons lined it with stone and cement.

Appius Fluvius, the chief water engineer, rode out from the city once a week to inspect construction. The foremen and laborers lived in camp sites which moved with the aqueduct farther and farther from the city. For twenty miles the aqueduct ran alongside the main highway, and the laborers would often stop



to watch the endless procession of merchants and farmers. About three years after construction began, large numbers of families could be seen traveling toward the city. Many belonged to the soldiers stationed in Verbonia. During the fifth year of construction the aqueduct turned away from the highway and two years later it was completed.

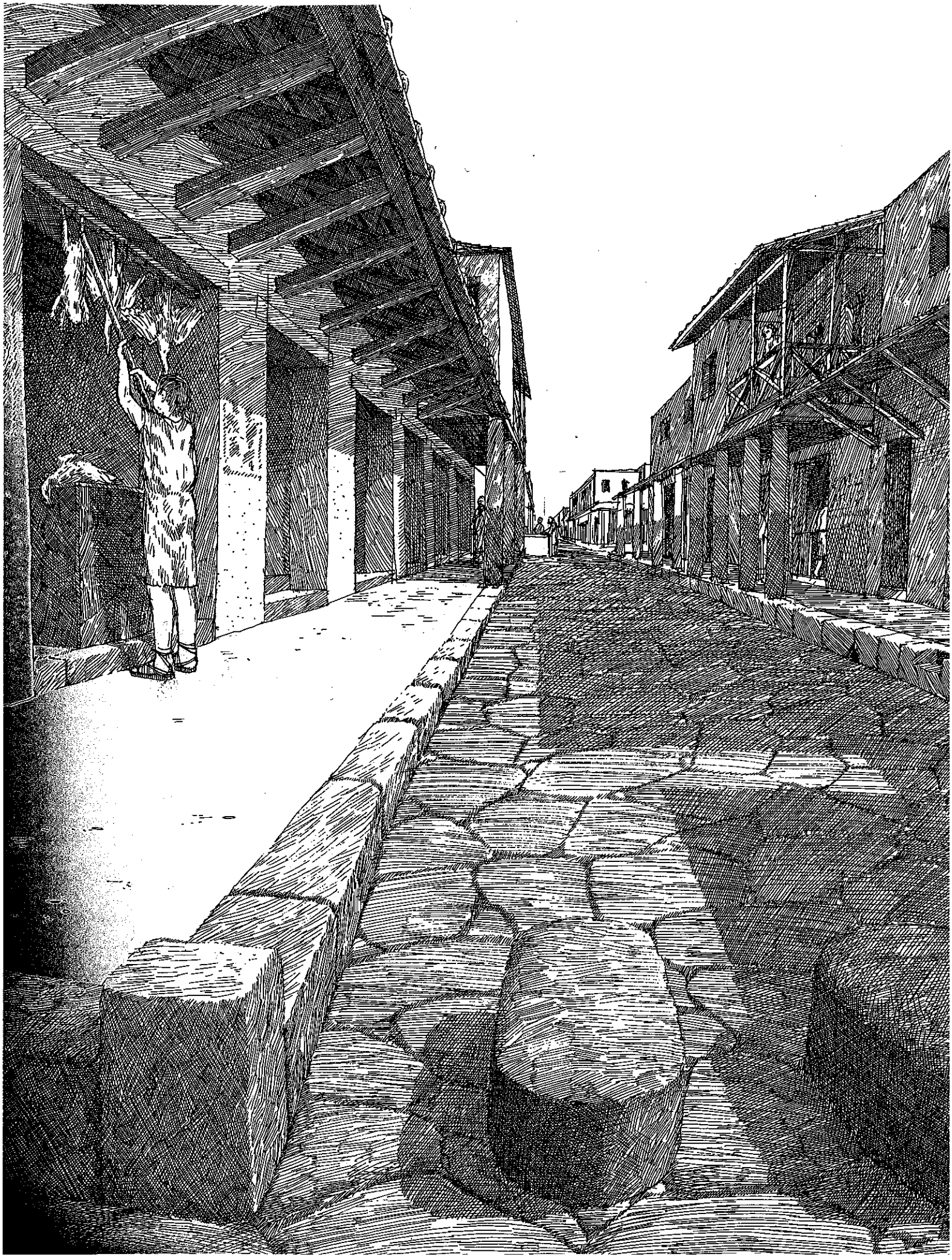




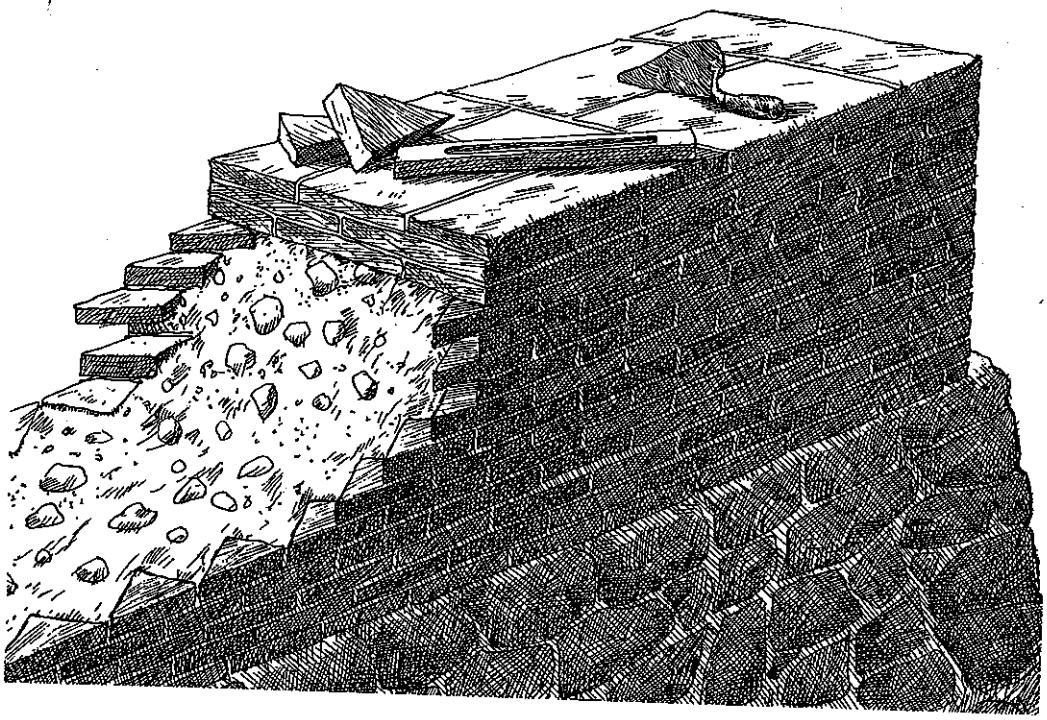
Before the wall of the city was finished, work began on the streets. Verbonia's streets were designed for people. Therefore adequate sidewalks were built and strict laws were written to control any movement of carts and chariots which could endanger the health and safety of people in the streets.

During the day all carts and chariots except those carrying building materials were banned from the streets. This meant that deliveries had to be made at night or in the early morning. Carts and horses were very noisy, so many of the streets on which people lived were made one way or dead end to reduce traffic.

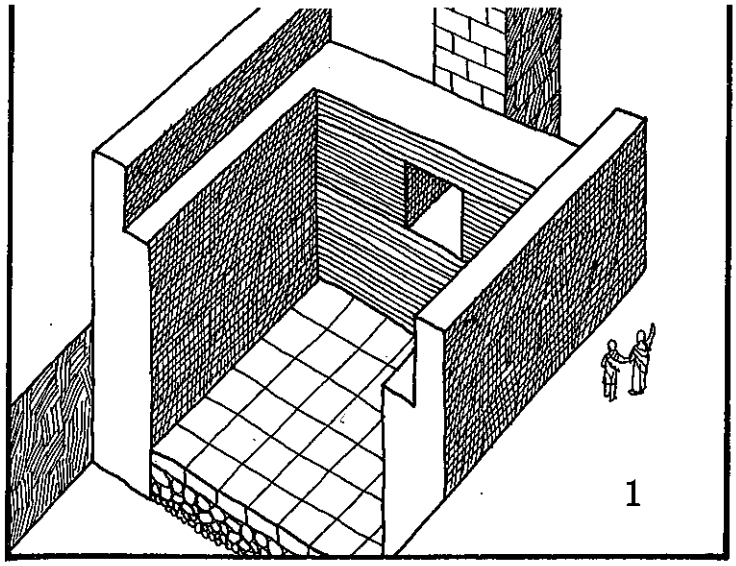
The sidewalks on both sides of the streets were raised one and a half feet above the road surface. This precaution prevented vehicles from accidentally rolling into the path of pedestrians. Steppingstones were embedded in the middle of the road to connect the sidewalks. Animals and carts could straddle the stones — but only if they went slowly. In this way the stones helped to enforce the speed limit. When it rained, the streets were the gutters through which water ran into sewers under the sidewalks. The steppingstones enabled people to cross the street without getting their sandals drenched. The cardo and decumanus were finished first. Other streets were completed as the area around them developed.



In 20 B.C. Appius and his staff started on the supply system that would distribute water throughout the city. The aqueduct was carried over the south wall and connected to two reservoirs. These were deep rectangular pools whose walls were brick-faced concrete — a wall of triangular bricks on the inside and outside enclosing layers of concrete. Every few feet the top of the wall was covered with three courses of large flat bricks. This allowed the contractor to adjust the level of the wall if it was not perfect.



Each reservoir was covered by a concrete tunnel vault. The vaults were constructed over a semicircular wooden form supported on scaffolding between the sides of the pool. Brick reinforcing arches were first constructed over the form ten feet apart. The entire form was then lined with flat bricks and covered with a thick layer of concrete. When the concrete hardened and could stand by itself the form was moved into the next position. Using the same form over and over, the process was repeated until the reservoir was covered. The brick facing on the inside surface of the vault and walls was covered with hard cement. The outside of the vault was shaped like a pitched roof and covered with tiles.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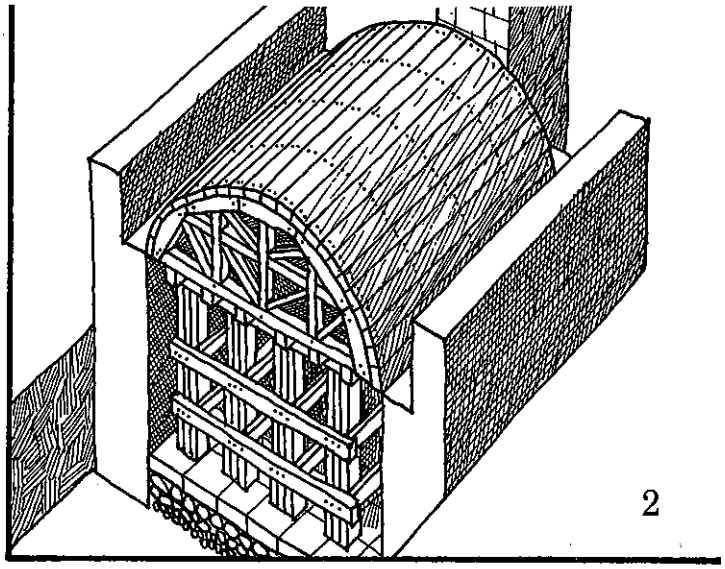
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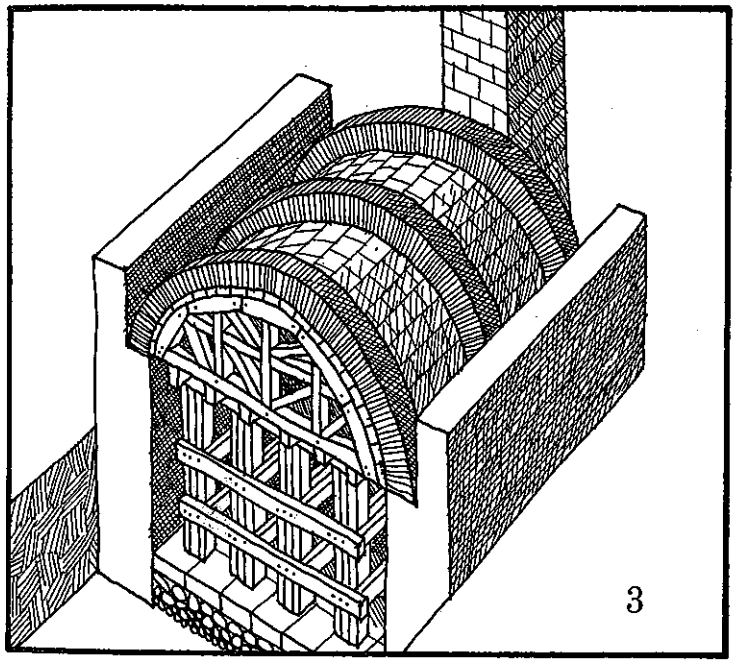
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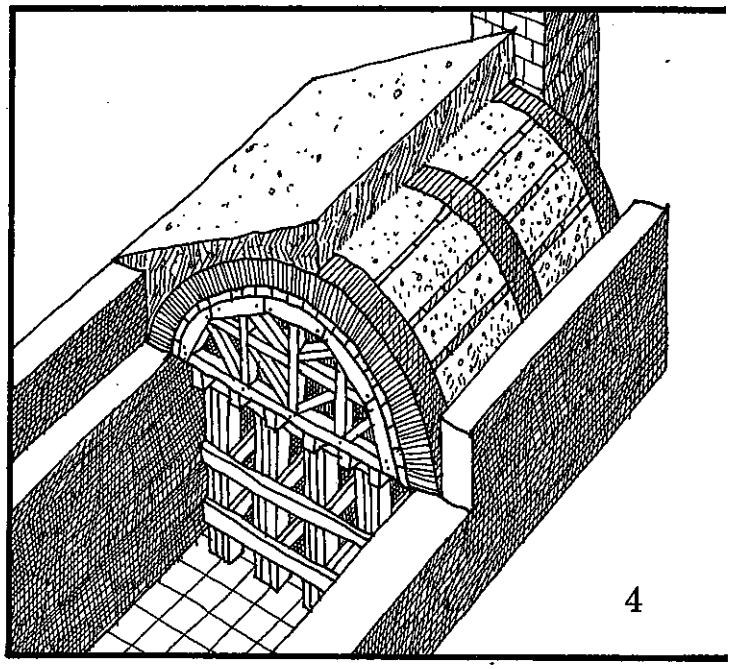
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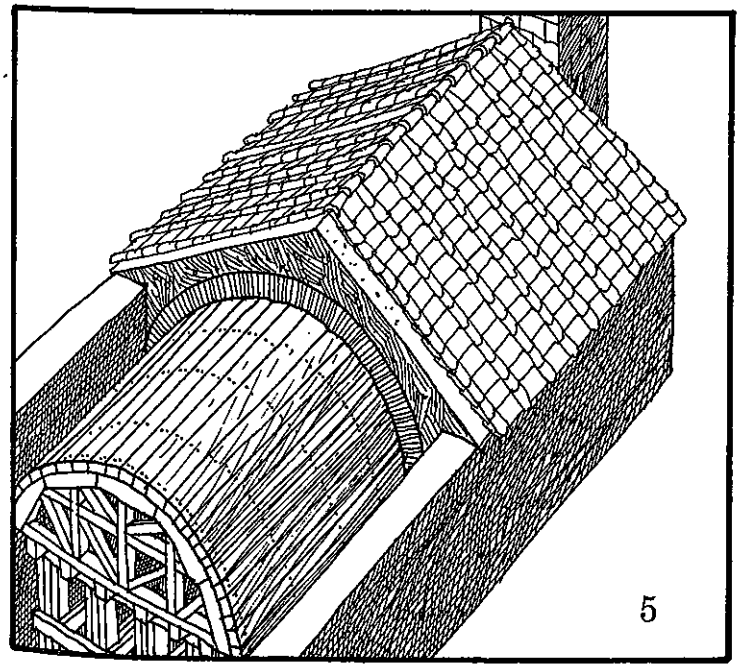
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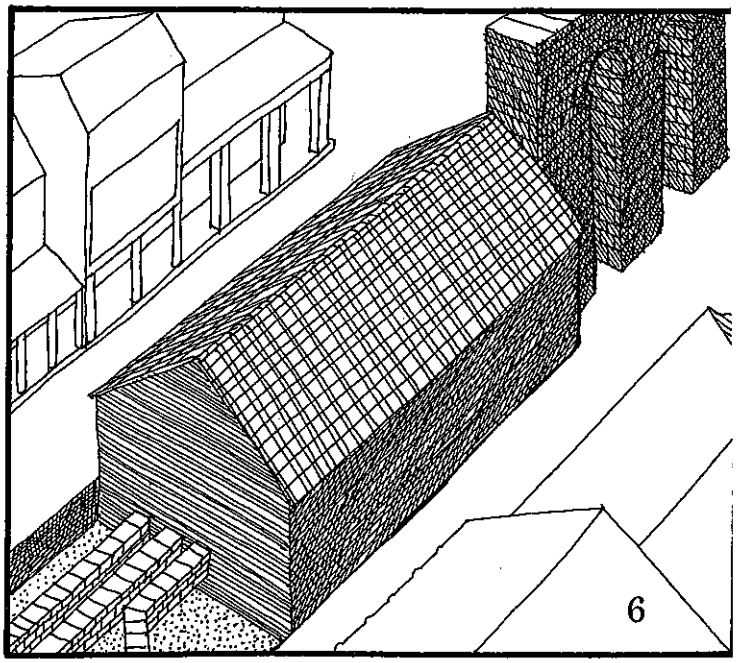
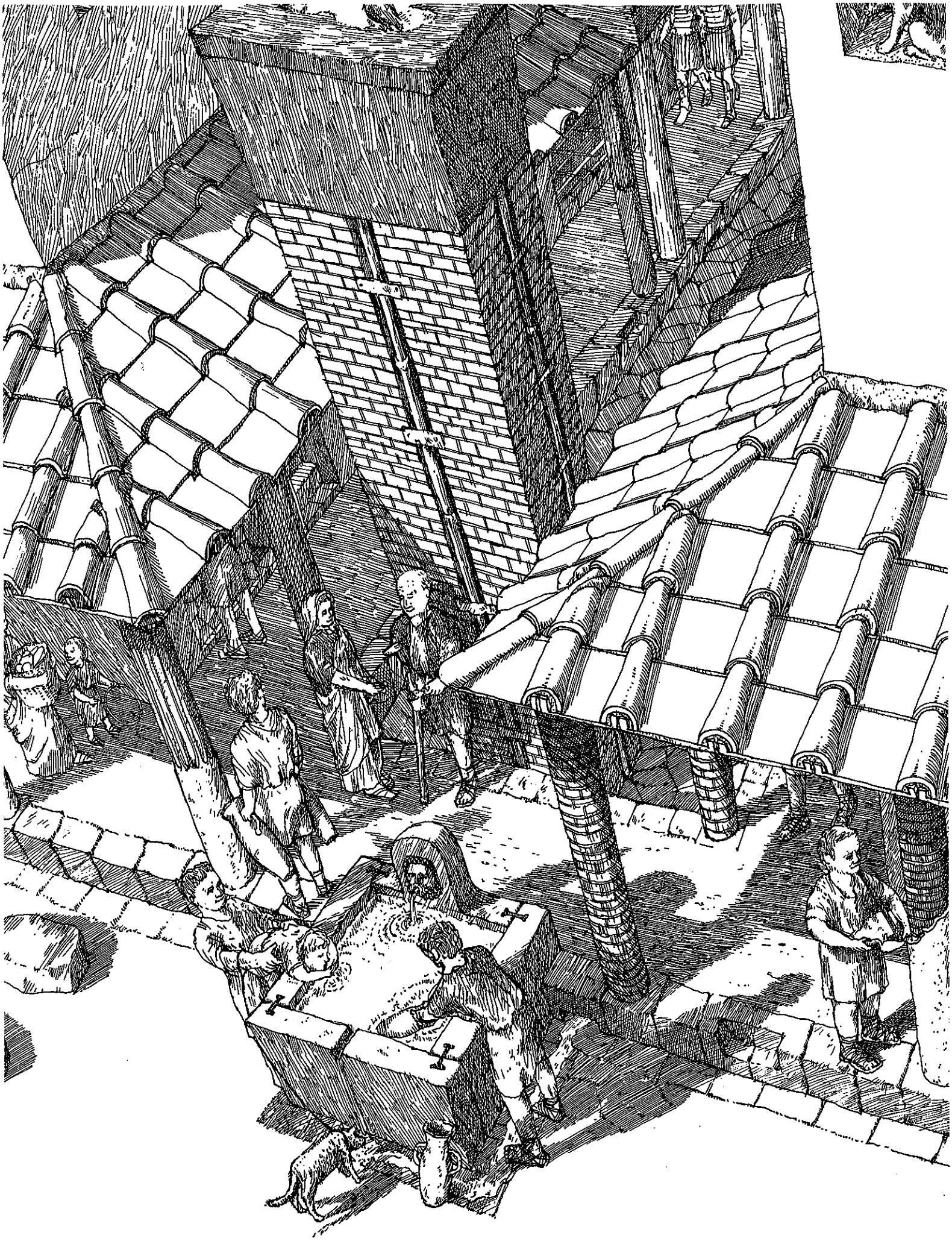
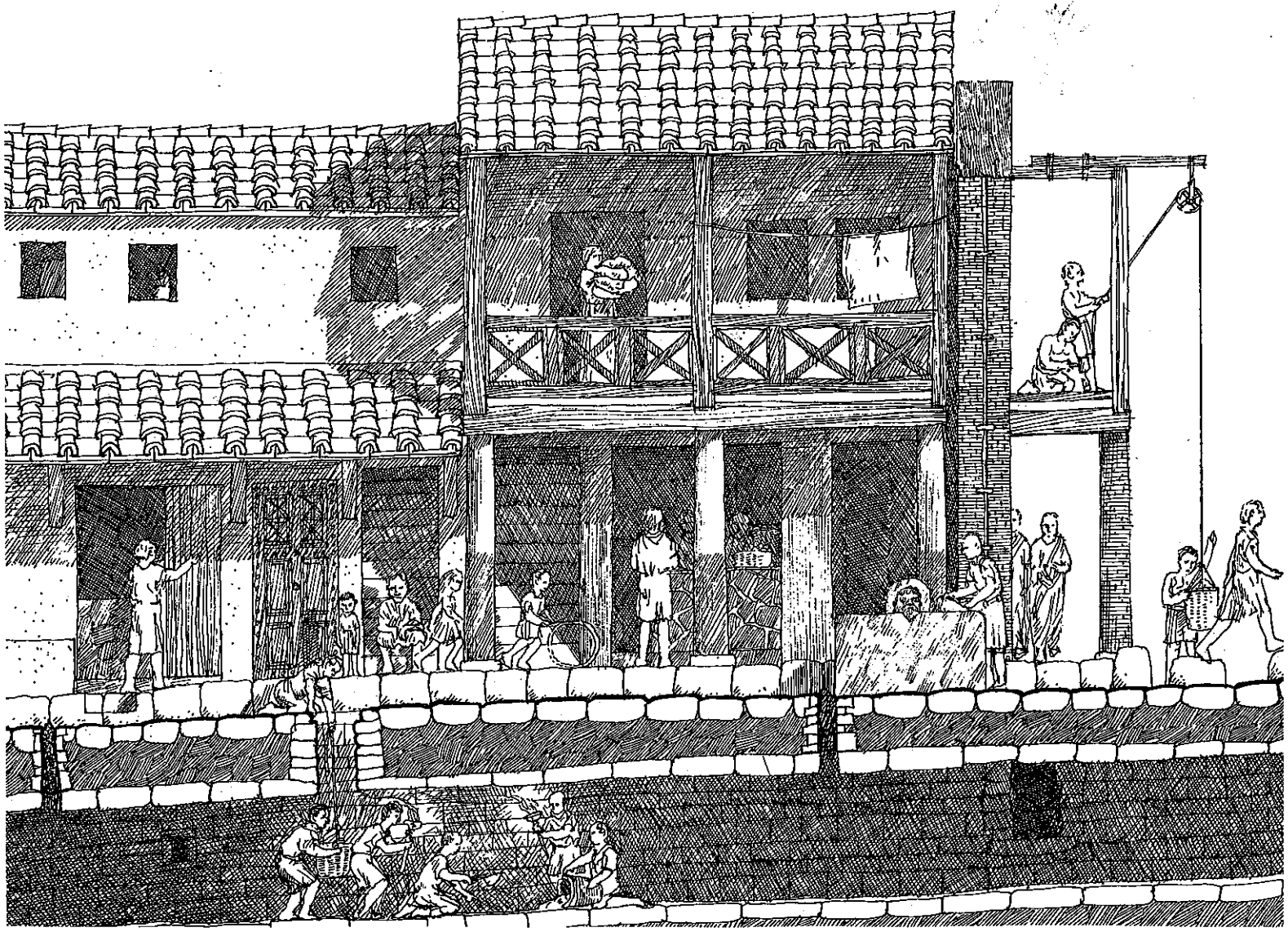

6

On the wall at one end of the reservoir were several gates channeling the water into lead pipes which ran either to public fountains, toilets, and baths, or to the homes of the wealthy. When there was a shortage of water, the gate leading to these homes was closed, and then, if necessary, the gate to the baths and toilets was closed as well. This insured that the public fountains supplying the majority of Verbonia's residents would be the last to run dry. The water for wealthy homes was first piped into a lead tank placed on one of many high brick towers. As it ran back down other pipes, the water gained enough pressure to feed all the houses to which the tower was connected.



In order for the water supply system to be efficient, an equally efficient drainage system was required. Sewers originally constructed under the sidewalks for rainwater were enlarged. They were connected to both public and private buildings by clay pipes. Some of the sewers were six feet deep. They were all built of stone and mortar and their tops were removable stone slabs in case repairs were necessary. The slabs were covered by compressed dirt in which the lead supply pipes from the water towers were laid.



All the sewers were connected to two cloacae — tunnels large enough to walk in — which carried the water under the walls of the city and down to the river. Iron grills were installed inside them which let the water out but prevented anyone from getting in.